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Patent No.	:	7,002,513	Confirmation No. 9454
Issued	:	February 21, 2006	
Appl. No.	:	10/810,247	
Applicants	:	Vernon Joseph Brabec	
	:	Clyde C. Goad	
	:	Alexander A. Khvalkov	
	:	Lev Borisovich Rapoport	
Docket No.	:	1010-0006-USA	

Certificate
APR 04 2006
of Correction

Title : ESTIMATION AND RESOLUTION OF CARRIER WAVE AMBIGUITIES IN A POSITION NAVIGATION SYSTEM

Attention: Certificate of Corrections Branch
Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313-1450.

REQUEST FOR CERTIFICATE OF CORRECTION UNDER 37 CFR 1.322

Patentee hereby requests a Certificate of Correction under 37 CFR 1.322 in order to correct PTO mistakes in the above identified patent.

The text of the requested corrections are set forth in the enclosed Certificate of Correction form PTO/SB/44, with the location of the errors in the printed patent identified by column and line numbers.

The requested corrections were incurred through the fault of the PTO. This request is supported by documentation showing that the requested corrections were included in the application as filed. This documentation includes copies of the relevant pages of the application as filed as well as a cross reference identifying the location of each error in the patent and its corresponding location in the application as filed.

I hereby certify that this correspondence, as well as any items referred to as being transmitted herewith, is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on March 28, 2006.

Typed or printed name of person signing this certificate: Risa Garcia

Signature: Risa Garcia

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Expedited processing of this Request is hereby requested.

Respectfully,

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PTO/SB/44 (04-04)
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(Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,002,513

DATED : February 21, 2006

INVENTOR(S) : Vernon Joseph Brabec, Clyde C. Goad, Alexander A. Khvalkov, Lev Borisovich Rapoport

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 6, line 13, "**1.16**", should read --**116**--.

Column 13, line 15, the equation (4) should read

$$--\varphi(X) = \left((X-T)^{'} C_{\|} (X-T)\right)^{\frac{1}{2}} \tan(\theta) - h^{'}(X-T) = 0\ --.$$

Column 14, line 46, "N and N" should read -- $\overline{N}$ and N --.

MAILING ADDRESS OF SENDER:

Law Office of Jeffrey M. Weinick, LLC
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PATENT NO. 7,002,513

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This collection of information is required by 37 CFR 1.322, 1.323, and 1.324. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1.0 hour to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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CROSS-REFERENCE OF ERRORS IN PATENT WITH LOCATION IN APPLICATION AS FILED

REQUEST FOR CORRECTION	LOCATION OF CORRECT TEXT IN APPLICATION AS FILED
Column 6, line 13, "**1.16**", should read --**116**--.	Paragraph 36, line 6
Column 13, line 15, the equation (4) should read -- $\varphi(X) = \left((X-T)^{'} C_{\parallel} (X-T)\right)^{\frac{1}{2}} \tan(\theta) - h^{'}(X-T) = 0$ --.	Paragraph 64, line 18
Column 14, line 46, "N and N" should read -- $\overline{N}$ and N --.	Paragraph 70, line 8

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quartz-crystal whereas each satellite clock is based upon a more accurate atomic reference clock. The receiver has the orbital patterns of the satellites stored in a memory, and it can determine the orbital position of the satellites based on the time of its clock. The receiver reads the timing marks on the satellite's signal, and compares them against it own clock to determine the transmission time from satellite to receiver.

[0035] The satellite's low-frequency (e.g., 50Hz) information signal provides the least precise timing information, the C/A-code signal provides the next most precise timing information, and the P-code signal provides the most precise timing information. The pseudo-range is determined from the low-frequency information signal and the C/A-code signal for civilian users and some military users, and is determined from the low-frequency information signal and the P-code signal for most military users. Accurate use of the P-code signal requires knowledge of a certain code signal that is only known to military users. Better precision than that provided by the P-code signal can be obtained by measuring the phase of the satellite carrier signal in a differential navigation DN mode using two receivers.

[0036] Fig. 1 shows a schematic drawing of an exemplary differential navigation system incorporating certain features of the present invention. The differential navigation system includes a Rover GPS unit 110 and a Base GPS Unit 114. The location of the Base 114 is known and the system is attempting to determine the location of the Rover 110. As is well known in the art, Rover 110 receives signals from satellites 102, 104, 106, 108 via antenna 112. Similarly, Base 114 receives signals from satellites 102, 104, 106, 108 via antenna 116. The Base 114 transmits differential correction signals to the Rover 110 via communication channel 118. Communication channel 118 may be, for example, a wired or wireless connection. The techniques for determining the location of the Rover 110 in the illustrative system shown in Fig. 1 are well known in the art, for example as described in, Bradford W. Parkinson and James J. Spilker Jr., Global Positioning Theory and Applications, Volume 163 of Progress In Astronautics and Aeronautics, published by the American Institute of Aeronautics and Astronautics, Inc, Washington D.C., 1996.

[0037] A laser unit 120 associated with Base 114 transmits laser beam(s) 122 to an optical sensor 124 on the Rover 110 in order to precisely measure an elevation angle 126 between reference points on the Base and Rover. A local reference plane such as 128 is used for measuring the elevation angle. Additional details regarding the generation, transmission,

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fact that the corrected Rover position belongs to the surface of the cone, may be involved into the floating and fixed ambiguity estimation schemes.

[0064] Let us divide the matrix D_k and the vector R_k in the equation (1) into blocks in accordance with division of the vector of unknowns Y_k into three parts:

$$D_k = \left(\begin{array}{c|c|c} D_{xx,k} & D_{xt,k} & D_{xn,k} \\ \hline D_{tx,k} & D_{tt,k} & D_{tn,k} \\ \hline D_{nx,k} & D_{nt,k} & D_{nn,k} \end{array}\right), \qquad R_k = \begin{pmatrix} R_{x,k} \\ R_{t,k} \\ R_{n,k} \end{pmatrix} \tag{3}$$

We will omit the epoch index $_k$ for the sake of brevity wherever this does not lead to misunderstanding. Given the vector h let $C_{\|}$ be the orthogonal projection onto the local horizon plane

$$C_{\|} = I - hh^{'}$$

and

$$C_{\perp} = hh^{'}$$

is the matrix of orthogonal projection onto the direction h which is the orthogonal complement to $C_{\|}$.

Provided there are no measurements errors, the identity

$$\left\|C_{\|}(X-T)\right\| \tan(\theta) = \left\|C_{\perp}(X-T)\right\|$$

must hold.

Expanding last identity obtain that

$$\varphi(X) = \left((X-T)^{'} C_{\|}(X-T)\right)^{\frac{1}{2}} \tan(\theta) - h^{'}(X-T) = 0. \tag{4}$$

Let also introduce the quadratic penalty cost function for violation of the equation (4):

$$\Phi(X) = \tfrac{1}{2}\varphi(X)^2. \tag{5}$$

Note now that solution of the equation (1) is equivalent to minimization of the quadratic function

$$F(Y) = \tfrac{1}{2}\left\|(D_k Y_k = R_k)\right\|^2 = \tfrac{1}{2}(D_k Y_k - R_k)^{'}(D_k Y_k - R_k).$$

The equalities (1) and (4) will be treated by least squares minimizing the 'penalized' cost function

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[0067] Particularly, both Lenstra-Lenstra-Lovasz transformation and λ-decorrelation may be applied to the augmented matrix $\hat{D}_k$.

[0068] The observation vector consists of all navigation parameters comprising between satellites and Rover and between satellites and Base pseudo-ranges and carrier phases. The observation vector is involved into calculation of the right-hand side vector R_k in the equation (1) above.

[0069] The state vector consists of all unknowns to be estimated: X,Y,Z of the Rover, clock shift, ambiguity for all satellites and frequency bands. More precisely: X,Y,Z of the Rover, between Rover and Base clock shift, between Base and Rover difference of ambiguity for all satellites and frequency bands. The state vector estimated at the epoch k is denoted by Y_k in the equation (1) above.

[0070] The present invention does not replace or eliminate the "rounding of the float ambiguity vector to the nearest set of integers". Very generally speaking the term 'rounding off' depends on the norm one uses to measure the closeness of two vectors – floating and integer ambiguity in our case. The integer ambiguity resolution, or rounding off, may be considered as a solution to the problem: $\min_{N \in Z} \|N - \overline{N}\|$ where $\overline{N}$ is the floating ambiguity vector, Z is the integer valued n-dimensional space (or integer lattice), N is the integer-valued vector of ambiguity to be found, $\|\cdot\|$ stands for the norm we use to measure the closeness between two vectors $\overline{N}$ and N. Using the $\|\cdot\|_1$ norm (or sum of absolute values of the vector components) for $\|\cdot\|$ results in the 'rounding-off' in the usual sense as solution of the above minimization problem. We use another norm: weighted $\|\cdot\|_2$ or $\|\cdot\|_{D,2}$ which results in the minimization problem $\min_{N \in Z}(N - \overline{N})' D(N - \overline{N})$ (MP).

[0071] The present invention (as part of integer ambiguity resolution) replaces the matrix D with the augmented matrix $\hat{D}$, where the matrix D appears in the equation (1), the matrix $\hat{D}$ is defined in the equation (8). Also the floating point vector $\overline{N}$ as part of the state vector Y_k in (1) is replaced with the part of the state vector $\hat{Y}_k$ in (7).]

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